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SINTERING OF CERAMIC MIXTURES BASED ON NATURAL WOLLASTONITE

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The sintering conditions of materials in the $CaO – SiO_2$ system and their effect on properties controlling the sintering process are analyzed. Conditions for producing porous and sufficiently strong material with open porosity 45% and compressive strength 57 MPa molded at a unit pressure of 10 MPa are established.

In view of increasingly strict requirements imposed on the physicomechanical properties of ceramic articles and depletion of deposits in the European part of Russia, the use of new types of high-quality mineral resources is becoming significant. One of such materials is natural wollastonite, which has a needle-fibrous structure. It is widely used abroad to produce lining elements for casting, having a low charge and a sufficiently high strength with a low thermal conductivity.

There are scarce data on the compositions of wollastonite mixtures and related production technologies [1]. The quality of wollastonite articles to a large extent depends on its purity [2, 3]. An especially pure natural variety is Indian wollastonite. Products made of natural wollastonite do not undergo substantial volume changes in manufacture. A specific feature in the behavior of wollastonite-based materials in firing is the narrow sintering interval of wollastonite mixtures [4, 5]; consequently, the study of sintering conditions and some physicomechanical properties of materials is significant.

Previous studies [6, 7] corroborated the fundamental possibility of using natural wollastonite as a material for making heat-insulating ceramics. At present it is necessary to investigate the process of sintering of wollastonite mixtures in semidry molding with the aim of improving the strength properties of materials.

The purpose of our study is the investigation of sintering conditions of materials in the $CaO – SiO_2$ system.

Mixtures of natural wollastonite, a special sintering glass additive, and an inorganic silica sol binder were taken in the mass ratio of 64 : 16 : 20, molded in the form of cylinders by semi-dry molding on a MS-500 hydraulic press at a unit pressure of 10 – 50 MPa, and fired in a SVK-5163 electric furnace at temperatures between 850 and 1100°C with a 1-h exposure at the final temperature. The nature sintering process was judged by variations in physicomechanical properties of the samples obtained (Table 1).

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The most intense sintering was registered in the temperature interval of 1000 – 1050°C, in this case the mean density, linear shrinkage (in diameter and in height), and compression strength sharply increase. Open and true porosity and water absorption, accordingly, decrease.

The process of sintering of material based on wollastonite is more evident on the curves of linear shrinkage versus firing temperature (Fig. 1). The inflection points on the curves lie within the temperature interval of 1000 – 1050°C. The increase in compression strength with increasing firing temperature is nonlinear as well, and the maximum strength values correlate with the most intense sintering interval.

Thus, the optimum firing temperature for wollastonite-based materials ensuring complete sintering is 1050°C.

As the firing temperature increases, the thermal conductivity of materials (Table 1 and Fig. 1) increases in accordance with the theory of thermal conductivity of heat-insulating materials [8], which is due to the thermal conductivity of the continuous component phase, namely air, which grows with increasing temperature.

The sintering conditions of materials of the $CaO – SiO_2$ system and their effect on properties controlling the sintering process (mean density, porosity, linear shrinkage, and strength) were investigated.

As a consequence, conditions were identified that provide for sufficiently strong porous materials with open porosity 45%, compression strength 57 MPa, and thermal conductivity 0.39 W/(m · K) molded at a unit pressure of 10 MPa and sintered at 850°C with a 1-h exposure at the final temperature.

The temperature interval of wollastonite sintering is 1000 – 1050°C, which facilitates complete sintering and formation of the densest and strongest materials. The open porosity in this case was 27.5% and the compression strength was 151.9 MPa.

The possibility of obtaining stronger materials based on wollastonite opens new application areas. The high strength

TABLE 1

Temperature, °C	Means density of fired sample, g/cm^3	Porosity, %		Shrinkage		Water absorption, %	Compression strength, MPa	Thermal conductivity, W/(m · K)
		open	true	in diameter	in height			
Molding pressure 10 MPa								
850	1.57	45.0	45.1	3.8	5.4	28.8	57.6	0.39
900	1.63	42.6	42.9	4.8	13.4	26.2	49.6	0.41
1000	1.93	32.4	32.5	9.6	11.7	16.9	82.9	0.48
1050	2.00	27.5	29.3	14.4	20.5	14.3	151.9	0.50
1100	2.41	1.1	15.5	16.4	22.9	0.4	163.8	0.60
Molding pressure 30 MPa								
850	1.74	38.2	38.9	2.8	5.0	22.0	Not determ.	0.43
900	1.88	33.0	34.0	4.0	10.4	17.5	The same	0.47
1000	2.14	22.8	24.9	7.2	12.3	10.6	″	0.53
1050	2.39	11.1	19.6	9.2	15.4	4.9	″	0.57
1100	2.32	1.0	18.6	10.0	19.1	–	″	0.58
Molding pressure 50 MPa								
850	1.86	32.7	34.7	1.6	5.7	17.5	″	0.46
900	1.96	29.3	31.2	3.2	8.5	15.0	″	0.49
1000	2.21	16.1	22.4	6.4	11.7	7.3	″	0.55
1050	2.33	2.0	18.2	6.8	11.3	0.8	″	0.58
1100	2.32	0.5	18.6	7.6	15.7	0.2	″	0.58

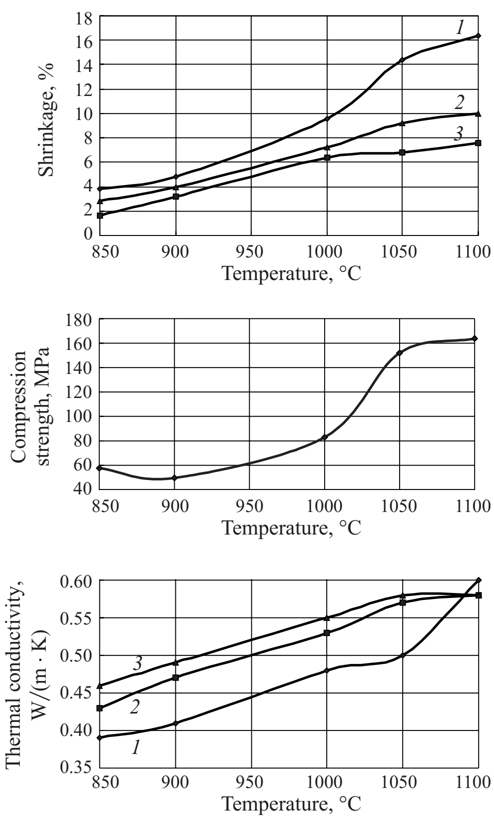

Fig. 1. Dependence of linear shrinkage (along the sample diameter), compression strength, and thermal conductivity on firing temperature: *1*, *2*, and *3*) unit molding pressure of 10, 30, and 50 MPa, respectively.

and porosity, low thermal conductivity, and nonwettability in aluminum alloys make ceramic materials based on natural wollastonite resistant to such alloys, which is very significant in the production of heat-insulating ceramics for lining of casting equipment and checkers in metallurgy and the automobile industry.

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